IKONOS Stereo Imagery Accuracy Assessment

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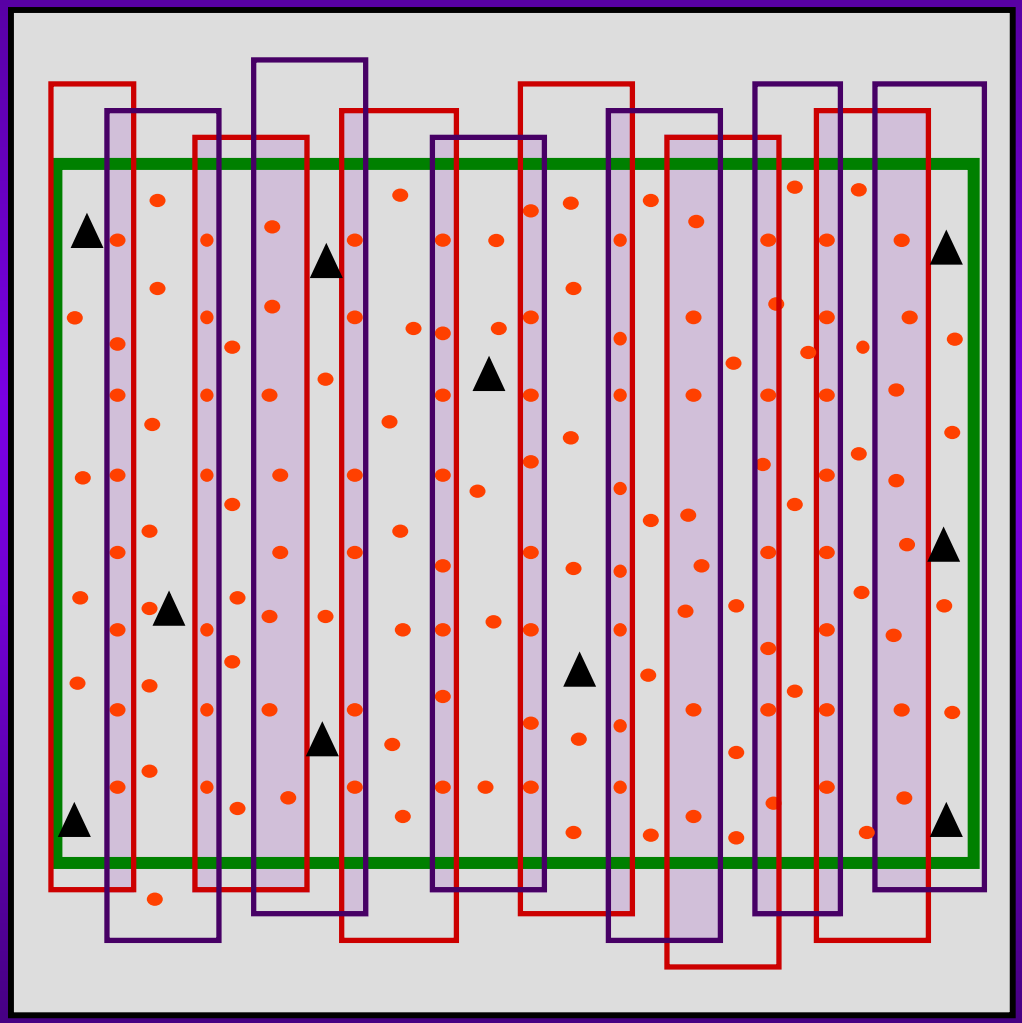
Purpose

- Evaluate geometric accuracy of IKONOS stereo imagery
  - IKONOS Accuracy Specification
    - Horizontal: 25 m (CE90)
    - Vertical: 22 m (LE90)
- Test cases included individual stereo pairs as well as triangulated blocks of overlapping strips
- Image strips were triangulated with varying numbers of ground control points
- This test evaluated the IKONOS rigorous sensor model as well as an adjustable form of the RPC polynomial model

Pushbroom Collection



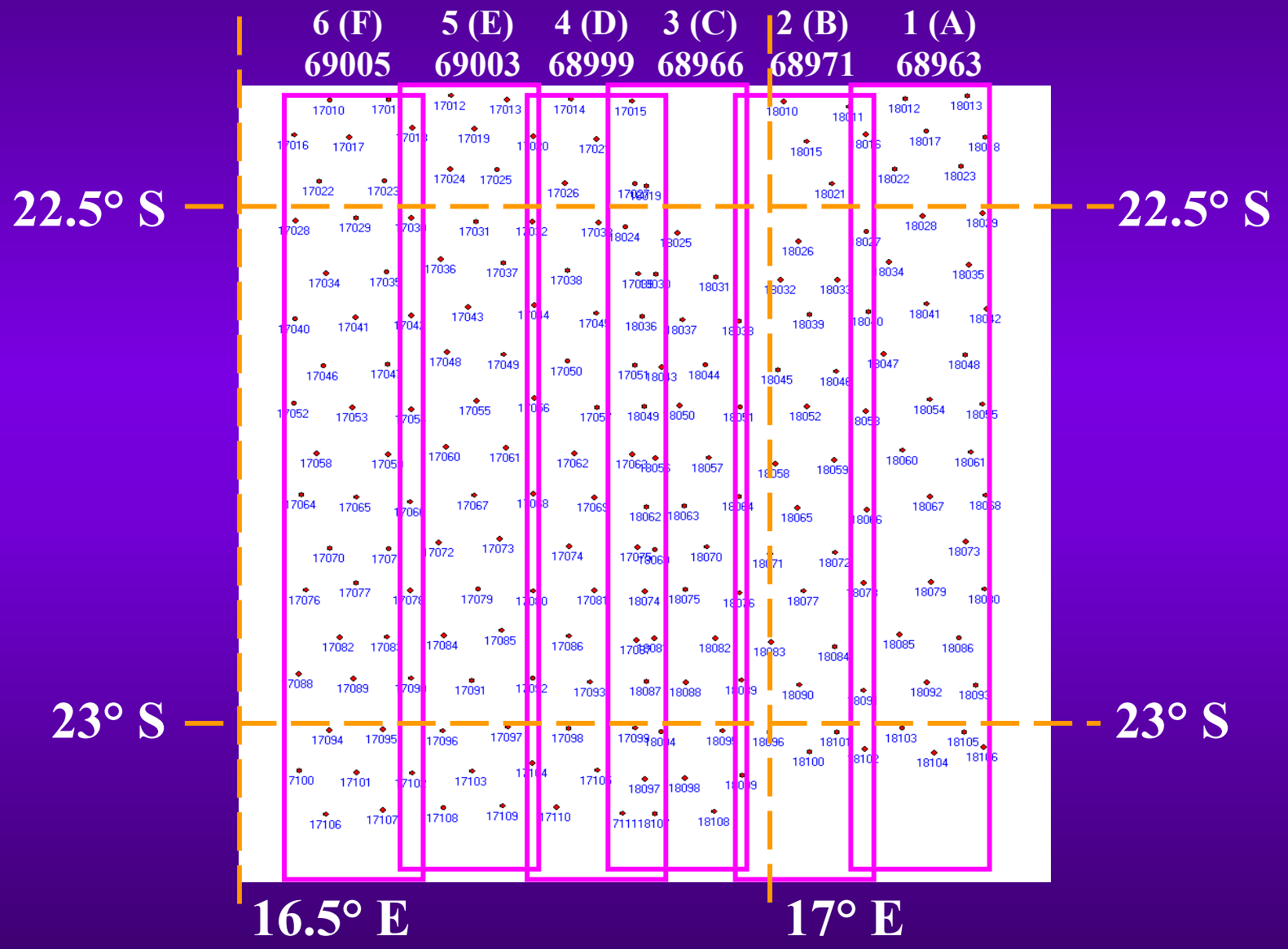
Accuracy Considerations

- Stable attitude measured via gyros and star trackers
- GPS Selective Availability has been turned off
- Multiple north-south strips in single rectangle
- Near-Nadir stereo view
- Potential for impressive accuracy

Description of Test Cases

- **Panchromatic Stereo Imagery**
  - Rectified with RPC support data
- **Test Sites**
  - Namibia, Africa
  - Nellis Test Range, Nevada
- **Test Case Combinations**
  - Individual strips
  - Sequential processing of overlapping strips
  - Processing of full block of overlapping strips
  - Various combinations of control points
  - Space Imaging block adjust via rigorous geometry model
  - NIMA adjustment using adjustable form of RPC model

Namibia Strips



Namibia Results
Individual Strips

Absolute Accuracy

Strip	CE90	LE90
A	9.4 m	7.4 m
B	3.9 m	8.6 m
C	9.6 m	6.4 m
D	12.7 m	15.7 m
E	9.1 m	3.5 m
F	9.0 m	15.9 m

Relative Accuracy

Strip	CE90	LE90
A	4.7 m	9.8 m
B	4.7 m	3.6 m
C	3.0 m	3.1 m
D	5.0 m	5.8 m
E	5.3 m	5.0 m
F	3.6 m	2.1 m

No Adjustment
RPC Support Data
Well within Accuracy Specifications

Namibia Results
Sequential Strips without GCPs

Absolute Accuracy

Block	CE90	LE90
AB	7.9 m	3.4 m
ABC	11.1 m	5.7 m
ABCD	10.2 m	20.5 m
ABCDE	12.3 m	13.2 m
ABCDEF	15.7 m	18.3 m

Relative Accuracy

Block	CE90	LE90
AB	7.1 m	5.3 m
ABC	8.7 m	4.2 m
ABCD	10.3 m	9.0 m
ABCDE	12.8 m	11.1 m
ABCDEF	15.0 m	11.4 m

Block Adjust with Rigorous Model

Sequential Adjustment Degraded Accuracy

Horizontal Bias on West Edge of Strips

Affects Both Absolute and Relative Accuracy

Namibia Results
Sequential Strips without GCPs

Absolute Accuracy

Block	CE90		LE90	
	Rigorous	RPC	Rigorous	RPC
AB	7.9 m	7.2 m	3.4 m	4.0 m
ABC	11.1 m	9.9 m	5.7 m	4.0 m
ABCD	10.2 m	11.0 m	20.5 m	6.3 m
ABCDE	12.3 m	13.3 m	13.2 m	5.1 m
ABCDEF	15.7 m	14.4 m	18.3 m	5.5 m

Block Adjust of Rigorous vs. Adjustable RPC

Adjustable RPC model better in vertical

Namibia Results
Sequential Strips with GCPs

Absolute Accuracy

Block - GCPs	CE90	LE90
D - 1	7.1 m	3.9 m
D - 8	2.3 m	2.7 m
CDE - 5	5.2 m	5.8 m
CDE - 25	4.6 m	4.4 m
ABCDEF - 1	11.1 m	9.8 m
ABCDEF - 18	8.0 m	7.2 m

Relative Accuracy

Block - GCPs	CE90	LE90
D - 1	3.4 m	3.2 m
D - 8	3.2 m	2.8 m
CDE - 5	7.2 m	7.8 m
CDE - 25	6.6 m	5.6 m
ABCDEF - 1	15.6 m	11.2 m
ABCDEF - 18	11.6 m	8.7 m

Block Adjust with Rigorous Model

Full Benefit of GCPs Muted by Bias Problem

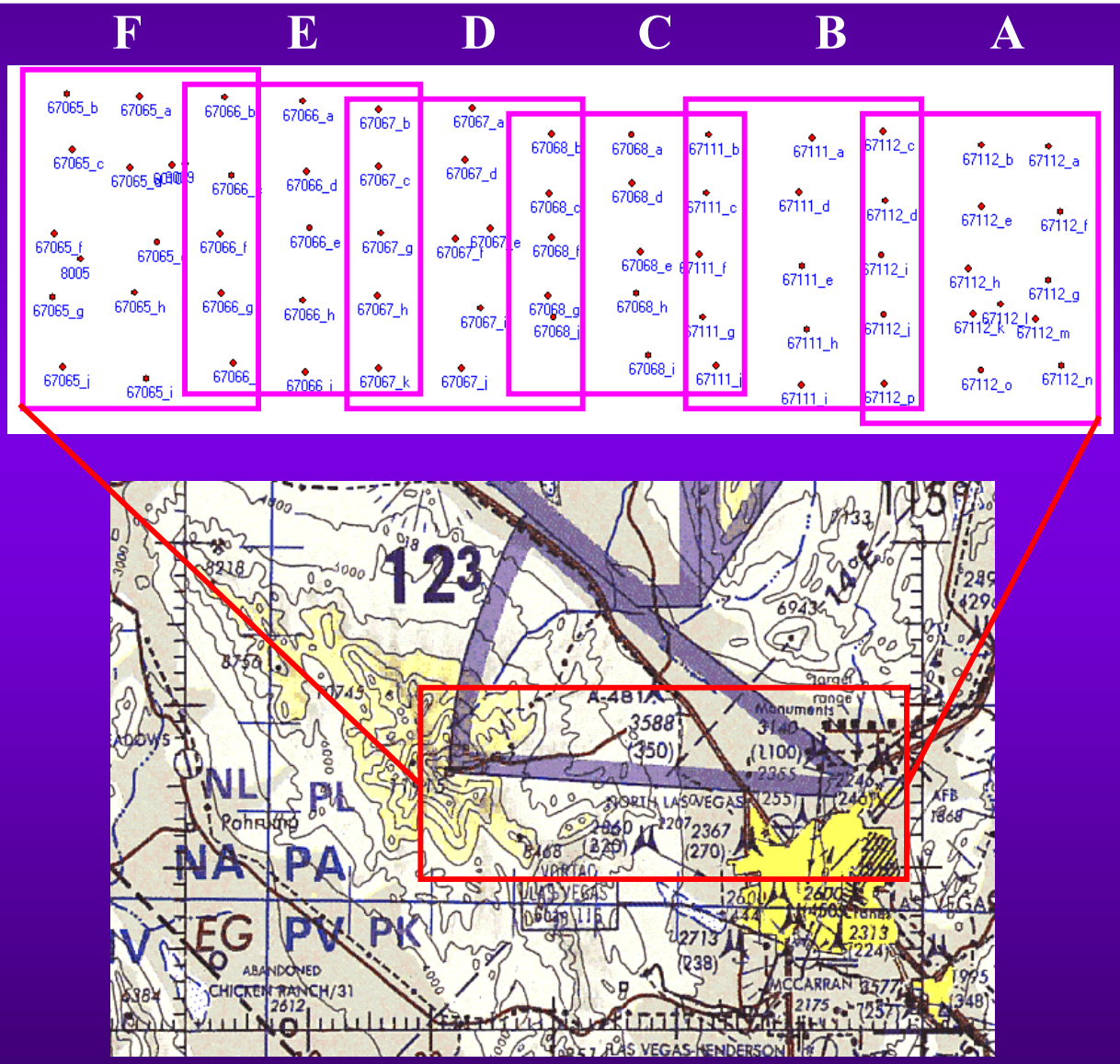
Namibia Results
Sequential Strips with GCPs

Absolute Accuracy

Block - GCPs	CE90		LE90	
	Rigorous	RPC	Rigorous	RPC
D - 1	7.1 m	4.3 m	3.9 m	8.8 m
D - 8	2.3 m	4.0 m	2.7 m	3.7 m
CDE - 5	5.2 m	6.1 m	5.8 m	3.3 m
CDE - 25	4.6 m	5.4 m	4.4 m	2.5 m
ABCDEF - 1	11.1 m	10.1 m	9.8 m	3.8 m
ABCDEF - 18	8.0 m	7.2 m	7.2 m	3.2 m

Block Adjust of Rigorous vs. Adjustable RPC Model

Nellis Strips



Nellis Results
Individual Strips

Absolute Accuracy

Strip	CE90	LE90
A	6.7 m	8.9 m
B	8.2 m	7.5 m
C	10.5 m	15.3 m
D	15.2 m	14.3 m
E	10.2 m	8.3 m
F	13.0 m	7.4 m

Relative Accuracy

Strip	CE90	LE90
A	5.4 m	2.8 m
B	3.8 m	1.8 m
C	3.7 m	5.5 m
D	4.7 m	4.5 m
E	3.6 m	3.7 m
F	3.5 m	5.7 m

No Adjustment
RPC Support Data
Well within Accuracy Specifications

Nellis Results
Sequential Strips without GCPs

Absolute Accuracy

Block	CE90	LE90
AB	7.7 m	3.4 m
ABCD	14.1 m	3.5 m
ABCDE	15.3 m	4.2 m
ABCDEF	16.7 m	4.8 m

Relative Accuracy

Block	CE90	LE90
AB	6.6 m	2.9 m
ABCD	10.4 m	5.3 m
ABCDE	12.3 m	5.5 m
ABCDEF	14.6 m	5.5 m

Block Adjust with Rigorous Model

Sequential Adjustment Degraded Accuracy

Horizontal Bias on West Edge of Strips

Affects Both Absolute and Relative Accuracy

Nellis Results
Sequential Strips without GCPs

Absolute Accuracy

Block	CE90		LE90	
	Rigorous	RPC	Rigorous	RPC
AB	7.7 m	8.3 m	3.4 m	3.1 m
ABCD	14.1 m	13.1 m	3.5 m	5.2 m
ABCDE	15.3 m	14.3 m	4.2 m	7.5 m
ABCDEF	16.7 m	16.7 m	4.8 m	4.8 m

Block Adjust of Rigorous vs. Adjustable RPC Model

Nellis Results
Sequential Strips with GCPs

Absolute Accuracy

Block - GCPs	CE90	LE90
A - 1	2.8 m	2.2 m
ABC - 1	6.0 m	3.6 m
ABC - 5	5.6 m	2.9 m
ABCDEF - 1	10.1 m	4.2 m

Relative Accuracy

Block - GCPs	CE90	LE90
A - 1	5.1 m	2.6 m
ABC - 1	7.9 m	4.2 m
ABC - 5	7.8 m	4.4 m
ABCDEF - 1	14.0 m	6.0 m

Block Adjust with Rigorous Model

Full Benefit of GCPs Muted by Bias Problem

Nellis Results
Sequential Strips with GCPs

Absolute Accuracy

Block - GCPs	CE90		LE90	
	Rigorous	RPC	Rigorous	RPC
A - 1	2.8 m	4.7 m	2.2 m	2.7 m
ABC - 1	6.0 m	5.5 m	3.6 m	3.3 m
ABC - 5	5.6 m	4.4 m	2.9 m	3.3 m
ABCDEF - 1	10.1 m	9.2 m	4.2 m	3.4 m

Block Adjust of Rigorous vs. Adjustable RPC Model

Space Imaging
Scale-Error Correction

NIMA Re-processing of Nellis Data

Nellis Single Strips
After Scale Correction

Horizontal
Absolute Accuracy
Original vs Scale Correction

Strip	CE90 Original	CE90 Correction
A	6.7 m	8.9 m
B	8.2 m	3.1 m
C	10.5 m	3.4 m
D	15.2 m	6.8 m
E	10.2 m	3.6 m
F	13.0 m	5.3 m

No Adjustment
RPC Support Data

Nellis Sequential Strips without GCPs
After Scale Correction

Absolute Accuracy
Original vs Scale Correction

Block	CE90		LE90	
	Original	Correction	Original	Correction
AB	8.3 m	6.9 m	3.1 m	2.4 m
ABC		5.1 m		6.4 m
ABCD	13.1 m	3.4 m	5.2 m	5.1 m
ABCDE	14.3 m	2.9 m	7.5 m	2.8 m
ABCDEF	16.7 m	2.9 m	4.8 m	3.1 m

Block Adjust with Adjustable RPC Model

Summary

Original Data

- Accuracy of individual stereo strips were well under accuracy specifications
  - Absolute Accuracy ranged from 7 to 15 meters
  - Relative Accuracy less than 6 meters
- Adjustment of multiple strips caused accuracy to degrade
  - Somehow related to western edge horizontal bias
  - Space Imaging has evaluated this error and implemented a correction
- Value of GCPs not fully demonstrated due to bias effect

Summary

Scale Correction Data

- Accuracy of individual stereo strips under 10 meters
  - No Control Points used
- Adjustment of multiple strips caused accuracy to improve
  - Multi-strip accuracy under 5 meters without control points
- Value of GCPs not yet tested by NIMA
  - Expect further accuracy improvement

NIMA has only processed one site with this new correction ...

Summary

- The Adjustable form of RPC Model matched the Rigorous model
  - However, this is a new approach to a bundle adjustment and requires further consideration
    - Interpretation of the 6 image-space terms
    - Error propagation
- This study is based on a limited sample
  - Only two test sites
  - NIMA should implement an on-going evaluation program over globally distributed control
- Commercial Push-broom satellites are well suited to mapping and targeting applications

Backup

Accuracy Computations in This Study

- Absolute Accuracy
  1) Mean difference computed between GCPs and IKONOS-derived coordinates
  2) 90% normal distribution computed about mean
  3) Added to mean to approximate 90% CE and LE
- Relative Accuracy (Point-to-point)
  1) Residual difference computed for each point between GCPs and IKONOS-derived coordinates
  2) Difference in residuals computed for each point pair
  3) Mean and 90% normal distribution computed using all point pairs
  4) Added to mean to approximate 90% CE and LE
     (Note: Negative LE90 values indicate bias direction)